Docket No. 30205/39513

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICATION FOR UNITED STATES LETTERS PATENT

Title:

METHODS FOR FORMING FINE PHOTORESIST PATTERNS

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METHODS FOR FORMING FINE PHOTORESIST PATTERNS

Technical Field

The forming of fine photoresist patterns using a tri-layer resist process is disclosed which overcomes problems associated with bi-layer resist processes. As disclosed herein, when a fine photoresist pattern is formed using a silicon photoresist, a gas protection film is coated on a photoresist to prevent exhaustion of silicon gas generated from the photoresist in light examination of high energy. As a result, contamination of the lens of the exposure equipment can be prevented.

Description of the Related Art

As the size of photoresist pattern used in a semiconductor processes becomes smaller, the thickness of photoresist must be thinner. However, as the thickness of photoresist becomes thinner, the photoresist does not adequately serve as an etching mask in a subsequent etching process. In order to overcome this drawback, a bi-layer resist process has been introduced.

Figs. 1a to 1d show the general bi-layer resist process.

Referring to Fig. 1a, a layer 30 is coated on an underlying layer 20 of a semiconductor substrate 10. The layer 30 is used as an etching mask when the underlying layer 20 is etched. The etching mask layer 30 is generally an i-line photoresist hardened at a high temperature.

A photoresist 40 which responds to light is coated on the etching mask layer 30. Here, the photoresist 40 includes silicon. The above-stacked structure is exposed using an exposure mask 50.

After the exposure process shown in Fig. 1a, a wet development process is performed to form a photoresist film pattern 42 as shown in Fig. 1b.

A dry etching process is performed using the photoresist film pattern 42 as an etching mask with O2 plasma. Here, the photoresist film pattern 42 including silicon is changed a silicon oxide film 60 by oxygen.

The lower etching mask layer 30 is etched using the silicon oxide film 60 as an etching mask to form an etching mask pattern 32 shown in Fig. 1c.

Next, the underlying layer 20 is etched using the etching mask pattern 32 formed in Fig. 1c. Then, a cleaning process is performed to form an underlying layer pattern 22 shown in Fig. 1d.

In order to reduce the size of patterns, high-energy light sources such as ArF (193nm), VUV (157nm) or EUV (13nm) are used in a photolithography process. However, when the exposure process is performed using a high-energy light source, the combination of resins in the photoresist is broken down to generate undesired by-product gases. In the case of photoresist including silicon, silicon gas is created. The silicon gas generated by the exposure process reacts to air and the silicon is transformed into SiO2 and then deposited on the lens. There is no known method for removing SiO2 , and the expensive lens of the scanner and the stepper must be frequently replaced.

As a result, it is expensive to use the bi-layer resist process with a photoresist that includes silicon.

SUMMARY OF THE DISCLOSURE

A method of forming a fine pattern using a silicon photoresist is disclosed which prevents generation of silicon gas and the problems associated therewith.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1a through 1d are cross-sectional diagrams illustrating a conventional method of forming a photoresist pattern with a conventional bi-layer resist process.

Figs. 2a through 2d are cross-sectional diagrams illustrating a disclosed method of forming a photoresist pattern with a tri-layer resist process.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS

A method of forming a fine photoresist pattern is disclosed wherein a gas protection film is coated on the photoresist film created with a bi-layer resist process.

A disclosed method for forming a fine pattern comprises:

(a) coating an etching mask layer on an underlying layer;

(b) coating a photoresist film capable absorbing gas generated from the photoresist film on the etching mask layer;

(c) coating a gas protection film on the photoresist film;

(d) performing a photolithography process on the resulting structure to form a photoresist film pattern;

(e) etching the etching mask layer of the step (b) using the photoresist film pattern as an etching mask to form an etching mask pattern; and

(f) forming an underlying layer pattern by an etching process using the etching mask pattern.

Although the etching mask layer of the step (a) is not necessarily limited, an I-line photoresist or KrF photoresist having etching resistance to an underlying layer is preferably used.

Preferably, the photoresist used in the step (b) is one of photoresists for ArF (193nm), VUV (157nm) or EUV (13nm) including silicon.

The gas protection film of the step (c) is preferably water-soluble polymer material having excellent permeability to light. The gas protection film is capable of absorbing silicon gas generated from the underlying photoresist film upon exposure to light.

The water-soluble polymer material is preferably selected from the group consisting of poly(methyl methacrylate/acrylic acid), poly(methyl acrylate/acrylic acid), poly(dimethyl acrylate/methyl acrylate), poly(dimethyl acrylate/methyl methacrylate), poly(vinyl pyrrolidone), poly(dimethyl acrylate) and mixture thereof.

The light used ArF (193nm), VUV (157nm) or EUV (13nm).

The step (c) comprises:

(c-1) spin coating a gas protection composition on the resultant surface of (b); and

(c-2) baking the coated gas protection composition..

A disclosed method of forming a fine pattern in accordance with certain preferred embodiments will be described in detail with reference to the accompanying drawings.

Referring to Fig. 2a, an etching mask layer 130 is coated on an underlying layer 120 of a semiconductor substrate 110. The etching mask layer 130 is generally an i-line photoresist or KrF photoresist hardened at a high temperature.

A photoresist 140 which responds to light is coated on the etching mask layer 130. Here, the photoresist 140 includes silicon as described above. A gas

protection film 170 is spin coated on the photoresist 140, and exposed using an exposure mask 150.

A silicon gas generated from the photoresist film by the exposure process is adsorbed onto the gas protection film 170. As a result, exhaustion of the silicon gas into the exposure equipment is prevented, and lens of the exposure equipment are not damaged by the oxidized silicon gas (SiO_2).

After the exposure process of Fig. 2a, a photoresist film pattern 142 is formed via a wet development process.

Since the gas protection film 170 has excellent permeability to light, light reaches easily the lower photoresist film when the gas protection film 170 is exposed to light. Additionally, since the gas protection film 170 comprises a water-soluble polymer, it is easily removed by a wet development process.

A dry etching process using O_2 plasma is performed on the etching mask layer 130 using the photoresist film pattern 142 formed in Fig. 2b as an etching mask.

The photoresist film pattern 142 including silicon is transformed into a silicon oxide film 160 by oxygen. The lower etching mask layer 130 is etched using the silicon oxide film 160 as an etching mask to form an etching mask pattern 132 as shown in Fig. 2c.

The underlying layer 120 is etching using the etching mask pattern 132 formed in Fig. 2c. Then, a cleaning solution is performed on the resulting structure to obtain a desired an underlying layer pattern 122 as shown in Fig. 2d.

As discussed earlier, when a fine pattern is formed using a silicon photoresist in accordance with the disclosed method, a gas protection film is further coated on a photoresist to effectively prevent exhaustion of silicon gas generated by exposure. Accordingly, lens of exposure equipment may not be contaminated by silicon gas.